

THE
DESCRIPTION
AND VSE OF THE
double Horizontall Dyall.

TO
THE MOST NOBLE,
AND HOPEFUL GENTLE
MAN S^r. WILLIAM HOWARD
KNIGHT OF THE BATH, AND
SONNE TO THE RIGHT
HONORABLE AND IL-
LUSTRIOUS LORD,
THOMAS EARLE OF
ARUNDEL AND
SURREY, EARLE
MARSHAL OF
ENGLAND,
&c.



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double horizontal lines

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THE MOST NOBLE
AND HOPEFUL GENTL
MAN, WILLIAM HOWARD
KNIGHT OF THE BATH, AND
SOME OF THE MOST
HONORABLE AND
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THOMAS EARLE OF
WYNDHAM AND
CARRINGTON
MARSHAL OF
ENGLAND

LONDON
THOMAS NELSON & SONS

The description, and use of the double

Horizontall diall.

THere are upon the Plate two severall Dyals: That which is outermost, is an ordinary dial, divided into howers and quarters, & every quarter into three parts which are five minutes apeece: so that the whole hower is understood to containe 60. minutes. And for this Diall the shadow of the upper oblique, or slanting edge of the stile, or cock, doth serve.

The other dial, which is within, is the *projection of the upper Hemisphere, upon the plaine of the Horizon*: the *Horizon* it selfe is understood to be the innermost circle of the limbe: and is divided on both sides from the points of *East* and *West* into degrees, noted with 10. 20. 30. &c. as farre as need requireth: And the center of the Instrument is the *Zenith*, or *Verticall point*.

Within the *Horizon* the middle straight line pointing *North* and *South*, upon which the stile standeth is the *Meridian*, or twelve a clocke line: and the other short arching lines on both sides of it, are the *hower lines*, distinguished accordingly by their figures: and are divided into quarters by the smaller lines drawen between them: euery quarter containing 15. minutes.

The two arches which crosse the hower lines, meeting on both sides in the points of intersection of the fixe a clock lines with the horizon, are the two semicircles of the *Ecliptick*, or annuall circle of the sunne: the upper of which arches serueth for the *Summer halfe* yeare; and the lower for the *winter halfe* yeare: and are therefore diuided into 365. dayes: which are also

The description and use

distinguished into twelue months with longer lines, hauing their names let downe: and into tenths and fifts with shorter lines: and the rest of the dayes with pricks as may plainly be seene in the dyall.

And this is for the ready finding out of the *place of the Sunne* every day: and also for the shewing of the *Sunnes yearely motion* because by this motion the sunne goeth round about the heavens in the cōpasse of a year, making the foure parts, or seasons thereof, natmely the *Spring* in that quarter of the *Ecliptic* which beginnes at the *interseccion on the East* side of the dyall, & is therfore called the *Vernall interseccion*. Then the *Summer* in that quarter of the *Ecliptic* which beginneth at the *interseccion with the Meridian* in the highest point next the *Zenith*. After that *Autumne* in that quarter of the *Ecliptic* which beginneth at the *interseccion on the West* side of the dyall, and is therfore called the *Autumnnall interseccion*: and lastly the *Winter* in that quarter of the *Ecliptic*, which beginneth at the *interseccion with the Meridian* in the lowest point next the *Horizon*.

But besides this *yearely motion*, the *Sunne* hath a *diurnall* or *dayly motion*, whereby it maketh day and night, with all the diversities and inæqualities thereof: which is expressed by those other circles drawn crosse the *lower lines*; the midlemost whereof, being grosser then the rest meeting with the *Ecliptic* in the points of the *Vernall*, and *Autumnnall interseccions*, is the *Equinoctiall*: and the rest on both sides of it are called the *parallels*, or *diurnall arches of the sunne*, the two outermost whereof are the *Tropicks*, because in the the sun hath his furthest *digression* or *Declination* from the *Equinoctiall*, which is degrees $23\frac{1}{2}$: and thence beginneth againe to returne to-
wards

of the double Horizontall Diall.

wards the *Equinoctiall*. The upper of the two *Tropics* in this our Northern hemisphere is the *Tropic of Cancer* and the sunne being in it, is highest into the North, making the longest day of Summer : And the lower next the horizon is the *Tropic of Capricorne*, and the sunne being in it is lowest into the South, making the shortest day of winter.

Betweene the two *Tropics* and the *Equinoctiall*, infinite such *parallel circles* are understood to be contained: for the Sunne, in what point soeuer of the *Ecliptic* it is caryed, describeth by his *lacion* a circle parallel to the *Equinoctiall*: yet those *parallels* which are in the instrument, though drawn but to every second degree of *declination*, may be sufficient to direct the eye in imagining and tracing out through every day of the whole year in the *Ecliptic*, a proper circle which may be the diurnall arch of the sunne for that day. For vpon the right estimation of that imaginary parallel doth the manyfold use of this instrument especially rely: because the true place of the sunne all that day is in some part or point of that circle. Wherefore for the better conceiuing and bearing in mind thereof, every fift *parallel* is herein made a little grosser then the rest.

For this inner dyall serueth the shadow of the upright edge of the stile; which I therefore call the *upright shadow*.

And thus by the eye and view onely to behold and comprehend the course of the sunne, throughout the whole year for his annuall and diurnall motion, may be the first use of this instrument.

II use. To find the *declination* of the sunne every day.
Looke

The description, and use

Looke the day of the moneth proposed in the *Ecliptick*, and marke how many degrees the prick shewing that day, is distant from the *Equinoctiall*, either on the Summer or winter side, *viz.* North or South.

Example 1. What will the *declination* of the sunne be upon the eleventh day of *August*? Looke the eleventh day of *August*, & you shall find it in the sixth circle above the *Equinoctiall*: Now because each parallel standeth (as hath bin said before) for two degrees, the sunne shall that day decline Northwards 12. degrees.

Example 2. What declination hath the Sun upon the 24. day of *March*? Looke the 24. day of *March*, and you shall find it betweene the second & third northerne parallels, as it were an halfe and one fift part of that distance from the second: Reckon therefore 4. degrees for the two circles, and one degree for the halfe space: So shall the Sunnes declination be five degrees, and about one fift part of a degree northward that same day.

Example 3. What declination hath the Sun upon the 13. day of *November*? Look the 13. day of *November*, and you shall finde it below the *Equinoctial* ten parallels, and about one quarter which is 20. degrees and an halfe southward. So much is the declination. And according to these examples judge of all the rest.

III. Use. To find the diurnall arch, or circle of the sunnes course every day.

The sunne every day by his motion (as hath bin said) describeth a circle parallel to the *Equinoctiall*, which is either one of the circles in the dial, or some-where betweene two of them. First therefore seek the day of
the

of the double Horizonall Diall.

the moneth; and if it fall upon one of those parallels; that is the circle of the Sunnes course that same day: But if it fall betweene any two of the parallels, imagine in your minde, and estimate with your eye, another parallel through that point between those two parallels keeping still the same distance from each of them.

As in the first of the three former examples; The circle of the Sunnes course upon the 11. of August; shall be the very sixth circle above the Equinoctiall toward the center.

In example 2. The circle of the sunnes course upon the 24. of March shall be an imaginary circle between the second and third parallels, still keeping an halfe of that space, and one fift part more of the rest, from the second.

In example 3. The circle of the Sunnes course upon the 13. of Novemb: shall be an imaginary circle betweene the tenth and eleventh parallels below the Equinoctiall, still keeping one quarter of that space from the tenth.

III. Use. To find the rising and setting of the sunne every day.

Seek out (as was last shewed) the imaginary circle or parallel of the sunnes course for that day, and marke the point where it meeteth with the horizon, both on the East and West sides, for that is the very point of the Sunnes rising, and setting that same day, and the hower lines which are on both sides of it, by proportioning the distance reasonably, according to 15. minutes for the quarter of the hower, will shew the hower of the Sunnes rising on the East side, & the Sunnes setting on the West side.

V. use.

The description, and use

V. use. To know the reason and manner of the *Increasing and decreasing of the dayes & nights* throughout the whole yeare:

When the Sunne is in the *Equinoctiall*, it riseth and setteth at 6. a clock, for in the instrument the interfection of the *Equinoctial*, and the *Ecliptic* with the *Horizon* is in the fixe a clocke circle on both sides. But if the sunne be out of the *Equinoctiall* declining toward the *North*, the interfections of the parallel of the sunne with the *horizon* is before fixe in the morning, and after 6. in the evening: and the *diurnal arch* greater then 12. howers, and so much more great, the greater the northerne declination is. Againe, if the sunne be declining toward the *South*, the interfections of the parallel of the Sunne, with the *horizon* is after fixe in the morning and before fixe in the evening: and the *diurnal arch* lesser then 12. howers; and by so much lesser, the greater the southerne declination is.

And in those places of the *Ecliptic* in which the Sun most speedily changeth his declination, the length also of the day is most altered: and where the *Ecliptic* goeth most parallel to the *Equinoctial* changing the declination, but little altered. As for example, when the sunne is neere unto the *Equinoctiall* on both sides, the dayes increase and also decrease suddainly and apace; because in those places the *Ecliptic* inclinet to the *Equinoctial* in a maner like a streight line, making sensible declination. Againe when the sunne is neare his greatest declination, as in the height of Summer, and the depth of winter, the dayes keepe for a good time, as it were, at one stay, because in these places the *Ecliptic* is in a maner parallell to the *Equinoctiall*, the length of the day

of the double Horizontall diall.

day also is but little scarce altering the declination: And because in those two times of the year, the Sunne standeth as it were still at one declination, they are called the *summer solstice*, and *winter solstice*. And in the meane space the nearer every place is to the *Equinoctiall*, the greater is the diversity of dayes.

Wherefore we may hereby plainly see that the common received opinion, that in every moneth the dayes doe equally increase, is erroneous.

Also we may see that in parallels equally distant from the *Equinoctiall*, the day on the one side is equall to the night on the other side.

V I. Vse. *To find how farre the sunne riseth, and setteth from the true East and west points, which is called the sunnes Amplitude, ortive, and occasive.*

Seeke out (as was shewed in I I I. use) the imaginary circle, or parallel of the suns course, and the points of that circle in the *horizon*, on the East and West sides cutteth the degree of the *Amplitude* ortive, and occasive.

V II. Vse. *To finde the length of every day and night.*

Double the hower of the Sunnes setting, and you shall have the length of the day; and double the hower of the Sunnes rising, and you shall have the length of the night.

V III. Vse. *To finde the true place of the sunne upon the dyall, that is, the point of the instrument which answereth to the place of the sunne in the heavens at any time, which is the very ground of all the questions following.*

If the dyall be fixed upon a post: Looke what a clocke it is by the outward dyall, that is, looke what hower

The description and use

hower and part of hower the shadow of the *slanting* edge of the stile sheweth in the outward limbe. Then behold the shadow of the upright edge, and marke what point thereof is upon that very hower, and part in the inner dyall among the parallels, that point is the true place of the Sun at the same instant.

If the dyall be not fixed, and you have a *Meridian line* noted in any window where the Sun shineth: place the *Meridian* of your dyall upon the *Meridian line* given, so that the top of the stile may point into the North: and so the diall is as it were fixed, wherefore by the former rule you may find the place of the sunne upon it.

If the dyall be not fixed, neither you have a *Meridian line* but you know the true hower of the day exactly: hold the diall even and parallel to the *horizon*, moving it till the *slanting* edge of the stile cast his shadow justly upon the time or hower given: for then the dyall is truly placed, as upon a post. Seek therefore what point of the upright shadow falleth upon that very hower, and there is the place of the Sunne.

But if your dyall be loose, and you know neither the *Meridian* nor the tyme of the day. First, by the day of the month in the *Ecliptick* find the sunnes parallel, or diurnall arch for that day, then holding the dyall leuell to the horizon, move it every way untill the *slanting* shadow of the stile in the outward limbe, and the upright shadow in the sunnes diurnall arch, both shew the very same hower and minut, for that very point of the sunnes parallel, which the upright shadow cutteth, is the true place of the Sunne on the diall at that present.

But note that by reason of the thicknes of the stile,
and

of the double Horizontall diall.

and the bluntnesse of the angle of the upright edge, the Sunne cannot come unto that edge for some space before and after noone. And so during the time that the sunn shineth not on that upright edge, the place of the Sunne in the dyall cannot be found. Wherefore they that make this kind of double dyall, are to be careful to file the upright edge of the stile as thinne & sharpe as possible may be.

That which hath heere bin taught concerning the finding out the sunnes true place in the dyal, ought perfectly to be understood, that it may be readily, and dexterously practized, for upō the true performance thereof dependeth all that followeth.

IX. Vse. To find the hower of the day.

If the dyall be fastened upon a post: the hower by the outward dyall, or limbe is knowne of every one: & the upright shadow in the suns parallel, or diurnal arch will also shew the very same hower.

But if the dyall be loose, either hold it or set it parallel to the horizon, with the stile pointing into the North and move it gently every way untill the hower shewed in both dyals exactly agreeeth, or which is all one, find out the true place of the sunne upon the dyall, as was taught in the former question, for that point among the hower lines sheweth the hower of the day.

X. Vse. To find out the Meridian, and other points of the compasse.

First you must seeke the true hower of the day (by the last question) for in that situation the Meridian of the dyall standeth directly North and South: and the East pointeth into the East, and the west into the west, and the rest of the points may be given by allowing
dgr:

The description and use

degr : 11. $\frac{1}{2}$ unto every point of the compasse.

XI. Use. *To find out the Azimuth of the sunne, that is the distance of the Verticall circle, in which the sunne is at that present, from the Meridian.*

Set your dyall upon any plaine or flat which is parallel to the horizon, with the Meridian pointing directly North and South, as was last shewed: then follow with your eye the upright shadow in a streight line, till it cutteth the horizon; for the degree in which the point of intersection is, shall shew how farre the suns Azimuth is distant from the East and west points, and the complement thereof unto 90. shall give the distance thereof from the Meridian.

XII Use. *To find out the Declination of any Wall upon which the sunne shineth, that is, how farre that wall swergeth from the North or South, either Eastward or Westward.*

Take a board having one streight edg, & a line stricke perpendicular upō it; apply the streight edg unto the wal at what tyme the sun shineth upō it, holding the board parallel to the horizon: Set the dial thereon, & move it gently every way, untill the same hower and minute be shewed in both dyals: and so let it stand: then if the dial have one of the sides parallel to the Meridian, strike a line along that side upon the board, crossing the perpendicular, or else with a bodkin make a point upon the board, at each end of the Meridian, and taking away the instrument from the board, and the board from the wall, lay a ruler to those two points, & draw a line crossing the perpendicular: for the angle which that line maketh with the perpendicular, is the angle of the declination of the wall. And if it be a right angle, the

of the double Horizontall Diall.

the wall is exactly East or west: But if that line be parallel to the perpendicular, the wall is direct North or South without any declination at all,

You may also find out the declination of a wall, if the dyall be fixed on a post not very farre frō that wal; in this maner. Your board being applyed to the wal, as was shewed, hang up a thred with a plummet, so that the shadow of the thread may upon the board crosse the perpendicular line: make two pricks in the shadow & runn instantly to the dyall and looke the horizontall distance of the sunnes Azumith, or upright shadow from the Meridian. Then through the two pricks draw a line crossing the perpendicular: and upon the point of the interfection, make a circle æqual to the horizon of your instrument, in which circle you shall from the line through the two pricks measure the horizontall distance of the upright shadow, or Azumith from the Meridian, that way toward which the Meridian is: draw a line out of the center, to the end of that arch measured: and the angle which this last line maketh with the perpendicular, shal be æquall to the declination of the wall.

XIII. Vse. How to place the dyall upon a post without any other direction but its selfe.

Set the dyall upon the post, with the stile into the North, as nere as you can guesse: then moue it this way and that way, till the same hower and minute be shewed, both in the outward & inward dyals, by the several shadowes, as hath bin already taught, for then the dial standeth in its truest situation; wherefore let it be nailed downe in that very place.

XIIII. Vse. To find the height of the Sun at high noone every day.

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The description and use

Seeke out the diurnall arch or parallel of the sunnes course, for that day (by use I I I.) and with a paire of compasses setting one foot in the center, & the other in the point of intersectio of that parallel with the Meridian, apply that same distance, unto the semidiameter divided, for that measure shall therein shew the degree of the sunnes altitude above the horizon that day at high noone.

X V. Vse. *To find the height of the sunne at any hower or time of the day.*

Seeke out the diurnall arch, or parallel of the sunnes course for that day : and marke what point of it is in the very hower & minute proposed. And with a paire of compasses, setting one foot in the center, and the other in that point of the parallel, apply the same distance unto the semidiameter divided : for that measure shall shew the degree of the sunnes altitude above the horizon at that time.

And by this meanes you may find the height of the sunne above the horizon at every hower through out the whole yeare for the making of rings and cylinders and other instruments which are used to shew the hower of the day.

XV I. Vse *The height of the sunne being given to finde out the hower, or what it is a clocke.*

This is the converse of the former ; seeke therefore in the semidiameter divided the height of the sunne given. And with a payre of compasses setting one foot in the center and the other at that height, apply the same distance, unto the diurnall arch, or parallel of the sunne for that day : for that point of the diurnall arch, upon which that same distance shall light, is the true place of
the

of the double Horizontall Diall.

the sunne upon the dial, and sheweth among the hower lines, the true time of the day.

XVII. Use. *Considerations for the use of the instrument in the night.*

In such questions as concerne the night, or the time before sunne rising, and after sunne setting, the instrument representeth the lower hemisphere, wherein the southerne pole is elevated. And therefore the parallels which are above the *Æquinoctiall* toward the center, shal be for the southerne, or winter parallels: and those beneath the *Æquinoctiall*, for the Northerne or Summer parallels; and the East shall be accounted for West, and the west for East; altogether contrary to that which was before, when the instrument represented the upper hemisphere.

XVIII. Use. *To find how many degrees the sunne is under the horizon at any time of the night.*

Seeke the declination of the sun for the day proposed (by use I I.) And at the same declination on the contrary side imagine a parallel for the Sun that night: and marke what point of it is in the very hower & minute proposed: And with a paire of compasses, setting one foot in the center, and the other in that point of the parallel, apply that same distance unto the semidiameter divided: for that measure shall shew the degree of the sunnes depression below the horizon at that time.

XIX. Use. *To find out the length of the Crepusculum, or twilight, every day.*

Seeke the declination of the sun for the day proposed (by use I I.) And at the same declination on the contrary side imagine a parallel for the sun that night. And with a payre of compasses setting one foot in the center

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The description and use

ter, and the other at 72. degrees upon the semidiameter divided, apply that same distance, unto the sunnes nocturnall parallel: for that point of the parallel, upon which that same distance shal light, sheweth among the hower lines, the beginning of the twilight in the morning, or the end of the twilight in the evening.

XX. Vse. If the day of the month be not knowne, to find it out by the dyall.

For the working of this question, eyther the dyall must be fixed rightly on a post, or else you must have a true Meridian line drawne in some window where the sun shineth; wherefore supposing the dyall to be justly set eyther upon the post, or upon the Meridian, Looke what a clock is it by the outward dyall, and observe what point of the upright shadow falleth upon the very same minute in the inner dyall, and through that same point imagine a parallel circle for the sunnes course; that imaginary circle in the Ecliptic shall cut the day of the moneth.

These Instrumentall dyalls are made in brasse by Elias Allen dwelling over against S^t. Clements Church without Temple-barre.

FINIS.

